PATENT ABSTRACTS OF JAPAN

(11)Publication number : 05-006514
(43)Date of publication of application : 14.01.1993

(51)Int.Cl. G11B 5/31

(21)Application number : 03-183791
(22)Date of filing : 28.06.1991

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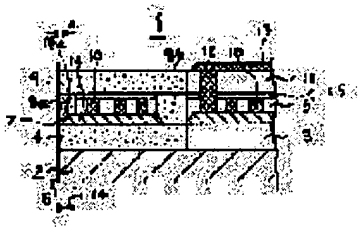
(54) THIN-FILM MAGNETIC HEAD

(57)Abstract:
PURPOSE: To enable recording on a high-coercive force medium to be carried out without having partial magnetic flux saturation of intermediate cores since the reduction in the thickness in the perpendicular direction from the medium- facing surface of the intermediate cores is prevented by a spacer even if a life size is set short and to obtain recording characteristics of good efficiency since the leakage of magnetic fluxes can be decreased by the spacer.
CONSTITUTION: This invention relates to an improvement of the thin-film magnetic head constituted by forming a lower core 4, an upper core 9 and the intermediate cores 8a, 8b connecting these cores of the magnetic materials in insulating layers 3, 5, 11, the front surfaces of these insulating layers including the connecting surfaces of the above-mentioned cores being approximately flat, and by forming a gap 7 in the juncture between the lower core 4 and the intermediate core 8a. The spacer layer 14 thicker than the gap 7 (layer) is formed between the lower core 4 and the intermediate core 8a holding the gap 7 (t<s).



LEGAL STATUS

[Date of request for examination]	18.03.1994
[Date of sending the examiner's decision of rejection]	
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	2658638
[Date of registration]	06.06.1997
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

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CLAIMS

[Claim(s)]
[Claim 1] The thin film magnetic head characterized by forming a spacer layer thicker than a gap layer between cores which sandwich a gap in the thin film magnetic head which the surface of each of said insulating layer where a bottom core, a top core, and a middle core that connects these are constituted by the magnetic substance in an insulating layer, and includes a connection side of each of said core is abbreviation flatness, and comes to form a gap in a connection of said core.
[Claim 2] The thin film magnetic head according to claim 1 characterized by being a material with an etching rate of a spacer layer material later than an etching rate of an insulating-layer material which is a work material.
[Claim 3] A spacer layer is the thin film magnetic head according to claim 1 or 2 characterized by having the shape of a taper to which thickness of an edge decreased toward a gap.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the suitable thin film magnetic head especially for high density magnetic recording with respect to the thin film magnetic head.
[0002]
[Description of the Prior Art] First, with reference to drawing 8 , the conventional structure and the conventional manufacture method of the thin film magnetic head 20 are explained. A magnetic film is formed on a substrate 21 and the bottom core 22 is formed by photolithography or etching. The nonmagnetic material 24 is formed so that an edge may serve as a gap (MAG) 23 on the bottom core 22. Next, an insulating layer 25 and a conductor layer are formed and it considers as the coil pattern 26 using photolithography, the etching method, etc. An insulating layer 27 and a magnetic layer are formed on the coil forming face which the coil pattern 26 was formed and the level difference attached, and it considers as the top core 28.
[0003] In the conventional thin film magnetic head 20, since an insulating layer 27 is formed on the coil pattern 26 with an insulating layer 25 and a level difference and the top core 28 is further formed on this insulating layer 27, whenever it piles up a layer, that level difference becomes large. For example, the thickness of both the usual cores is about 5 micrometers. Setting just before top core formation, when the thickness of a coil pattern is about 3 micrometers, a level difference is 10 micrometers. It reaches.
[0004] In the field top with such a level difference, the resolution by photolithography got extremely bad and the resolution of the magnitude degree of a level difference was a limit. Therefore, in order to make [many] the number of turns of a coil, even if it is going to form the pitch gap of the coil pattern 26 small, since resolution is bad, it cannot do small. Consequently, the length of the vertical cores 22 and 28 formed up and down needed to be made into size, magnetic reluctance became high by the increment in magnetic-path length, and there was a trouble that the engine performance worsened, as the thin film magnetic head.
[0005] The thin film magnetic head given in JP,3-58308,A for which these people applied previously is one of those solved such a trouble. This is the thin film magnetic head 30 which formed the slot of a core configuration in the insulating layer by etching, filled up the slot with the magnetic substance, carried out flattening of the surface, accumulated it, and formed the magnetic circuit, as shown in drawing 9 . As for a coil pattern, and 36, 37 and 38, the core which 31, 32a, 32b, and 33 become from the magnetic substance, and 35 are [an insulating layer and 39] magnetic gaps.
[0006]
[Problem(s) to be Solved by the Invention] There were the following troubles in said thin film magnetic head 30, it was highly efficient, and it difficult to offer the reliable thin film magnetic head. ** In from the field (slider side) where an arm head counters with data medium to the place which a gap begins to open, if a life size or the depth of gap and a call (l in drawing 9 and drawing 10), and this are large, the head life by wear will usually be extended. However, since magnetic reluctance will become large if too large, at the time of record, the leakage flux in the tip of a gap decreases, and effectiveness falls, and at the time of playback, in order for an output to decrease, it is necessary to set it as suitable length. For example, in the case of the floating head for magnetic disks, generally, a life size is set up before and after 1 micrometer. However, since the data-medium opposed face of a middle core and vertical thickness become thin like drawing 10 so that a life size is set up short, a part of magnetic pole tends to be saturated.
[0007] ** In order to process a core-like slot for example, by reactant dry etching (RIE) in the thin film magnetic head 30 like drawing 9 , an etching side wall tends to serve as a perpendicular configuration, it becomes perpendicular [the magnetic-substance (core) cross section by which pad formation was carried out] there, and the core for one layer

presents the letter of a block again. And since a ring-like magnetic circuit is formed as a whole by accumulating the core of such a letter of a block, it will have the square core cross-section configuration, and is hard to concentrate magnetic flux (G2 in drawing) at the tip of a magnetic gap as compared with the magnetic flux (G1 in drawing) of the thin film magnetic head shown in drawing 8 .

[0008]

[Means for Solving the Problem] In order to solve the above-mentioned trouble, a bottom core, a top core, and a middle core that connects these are constituted by the magnetic substance in an insulating layer, and this invention offers the thin film magnetic head in which a spacer layer thicker than a gap layer was formed between cores which sandwich a gap, in the thin film magnetic head which the surface of each of said insulating layer including a connection side of each of said core is abbreviation flatness, and comes to form a gap in a connection of said core.

[0009] In the thin film magnetic head constituted as mentioned above, since thickness L of a perpendicular direction from a data-medium opposed face of a core which sandwiches a gap with a spacer thicker than a gap layer does not become thinner than the life size l (L>l), there is no partial magnetic-flux saturation of a core. Moreover, since a spacer layer was formed between cores which sandwich a gap, leakage of magnetic flux decreases.

[0010]

[Example] One example of the thin film magnetic head which becomes this invention is explained to details with a drawing below. This thin film magnetic head is filled up with the magnetic substance, carries out flattening of the surface, it accumulates it on the slot, forms [the slot of a core configuration is formed in an insulating layer by etching, and] a magnetic circuit in it, and forms a spacer layer thicker than a gap layer further between the magnetic layers (core) whose magnetic gap layers are pinched.

[0011] [Example 1] Drawing 1 is an outline cross section showing the thin film magnetic head 1 which becomes this invention. As shown in this drawing, the slot which the flat lower insulating layer 3 is formed on the substrate 2, and was formed in this lower insulating layer 3 is filled up with magnetic material, and the bottom core 4 formed evenly without said lower insulating layer 3 and level difference is formed.

[0012] The middle insulating layer 5 is formed on the lower insulating layer 3, it is laid under the edge (record-medium opposed face 6) of this middle insulating layer 5 so that middle core 8a which consists of magnetic material may approach with the bottom core 4 through a gap (MAG) 7, and it is laid under the inside which separated this middle core 8a and distance so that middle core 8b which consists of magnetic material may join to the bottom core 4 directly. It is spirally laid under the interior of the middle insulating layer 5 so that the superficial coil patterns 10 may surround said middle core 8b. The end section of the coil pattern 10 joins to the external lead wire 13 through the conductor 12 buried in the through hole drilled in the up insulating layer 11, and an external device and electric connection are possible for it. In addition, 15 is the insulating layer of the coil pattern 10 and the top core 9.

[0013] Moreover, the up insulating layer 11 is formed on said middle insulating layer 5, the top core 9 is formed in this up insulating layer 11 so that both ends may join to the middle cores 8a and 8b, and the magnetic circuit is formed with said bottom core 4. Furthermore, the spacer layer 14 (thickness s) thicker than a gap (layer) 7 (thickness t) is formed on the top core 9 between the core 9 when inserting a gap 7, and middle core 8a (t<s). The thickness of edge 14a of the spacer layer 14 decreases toward a head point (the record-medium opposed face 6, gap 7), and edge 14a of the spacer layer 14 is a taper-like.

[0014] Thus, in the thin film magnetic head 1 which becomes this invention, three flat insulating layers 3, i.e., a lower insulating layer, the middle insulating layer 5, and the up insulating layer 11 are accumulated, and since the magnetic layer formed in the predetermined part in these insulating layers is connected and the magnetic circuit is formed, a photolithography becomes possible in respect of each insulating layer without a level difference. Therefore, since small coil pattern and magnetic core which was excellent in dimensional accuracy are obtained, magnetic reluctance is low and becomes possible [obtaining the powerful thin film magnetic head].

[0015] Furthermore, since thickness L of the perpendicular direction from the data-medium opposed face of middle core 8a does not become thin with a spacer 14 even if it sets up a life size (l in drawing) short, there is no partial magnetic-flux saturation of a core, and it becomes high coercive force data medium recordable. Moreover, since the leakage of magnetic flux can be decreased by forming a spacer (layer) 14, an efficient recording characteristic is acquired. Furthermore, since the magnetic field for a head point (a near gap) concentrates at the tip of a gap by making edge 14a of a spacer 14 into a taper configuration, efficient writing is attained.

[0016] Next, the manufacture method of the thin film magnetic head 1 is explained with reference to drawing 6 and drawing 7 .

The 1st production process (A of drawing 6)

a substrate 2 -- SiO2, TiO2, and WO3 etc. -- an insulating layer 3 -- 1-10 micrometers It forms in thickness by the

spatter, vacuum evaporationo, CVD, etc., and slot 4X of a core configuration is formed in it by photolithography and etching.

[0017] The 2nd production process (B of drawing 6)

The soft magnetism thin film which used Fe, Co, and nickel as the principal component is formed with a spatter, vacuum evaporationo, CVD, plating, etc. more thickly than the depth of said slot 4X, polishing removes an excessive upside magnetic layer, flattening of the surface is carried out, and it considers as the bottom core 4.

[0018] The 3rd production process (C of drawing 6)

Etching agent 4, for example, CF, About the low material (for example, CaTiO3, BaTiO3, ZrO2, alpha-Fe 2O3 grade) of an etching rate, it is 1-several micrometers to the dry etching to depend. Membranes are formed by a spatter etc. by thickness and the portion which a middle core (8a, 8b) and the bottom core 4 connect by methods, such as ion milling, is removed. This layer serves as a spacer 14 (thickness s). Moreover, a magnetic field can be made steeper by making edge 14a of a spacer 14 into a taper configuration. A taper configuration is easily acquired by choosing an ion beam incident angle suitably at the time of ion milling processing.

[0019] The 4th production process (D of drawing 6)

a bottom core 4 and spacer 14 top -- SiO2, TiO2, and WO3 etc. -- an insulating layer 5 -- 1-5 micrometers It forms.

[0020] The 5th production process (E of drawing 6)

the inside of an insulating layer 5 -- a core -- the same -- a coiled form slot -- etching -- forming -- conductors, such as Cu, aluminum, Au, and Ag, -- a film is formed with vacuum evaporationo, a spatter, plating, etc., polishing removes the upper excessive conductor, flattening of the surface is carried out, and it considers as a coil 10. Since it has considered as the material with an etching rate later than the insulating layer 5 whose spacer 14 is a work material at the time of formation of this coil slot, a spacer 14 works as an etching stopper, etching stops in the upper part of a spacer 14, and it prevents that etching advances to the bottom core 4. By the spacer 14, the electric insulation with a coil 10 and the bottom core 4 is taken.

[0021] The 6th production process (F of drawing 6)

the electric insulation with a top core (9) and a coil 10 sake -- SiO2, TiO2, and WO3 etc. -- insulating layer 15 0.1-1 micrometer It forms.

[0022] The 7th production process (G of drawing 6)

Slot 8aX of anterior part middle core 8a is formed by photolithography and etching. At this time, even the magnetic substance of the bottom core 4 does not etch slot 8aX, but it leaves by gap length, and a stop (thickness t) and the insulating layer which remained serve as a gap (MAG) 7 in etching. Since the spacer 14 which is in the middle of etching and is exposed has the small etching rate, most reduction of the thickness by etching does not have it.

[0023] The 8th production process (A of drawing 7)

Posterior part middle core slot 8bX is etched. At this time, slot 8bX is etched until it reaches the bottom core 4.

[0024] The 9th production process (B of drawing 7)

The soft magnetism thin film which used Fe, Co, and nickel as the principal component at slot 8aX of a middle core and 8bX is fabricated with a spatter, vacuum evaporationo, CVD, plating, etc. more thickly than the depth of flute, polishing removes an excessive upside magnetic layer, flattening of the surface is carried out, and it considers as the middle cores 8a and 8b.

[0025] The 10th production process (C of drawing 7)

middle core 8a and 8b top -- SiO2, TiO2, and WO3 etc. -- an insulating layer 11 -- 1-10 micrometers It forms.

[0026] The 11th production process (D of drawing 7)

The top core 9 as well as the bottom core 4 is formed in an insulating layer 11.

[0027] The 12th production process (E of drawing 7)

the insulating layer 11 of the upper layer of a coil 10 -- a through hole -- etching -- forming -- the inside of a through hole -- a conductor 12 -- being filled up -- conductors, such as Cu, aluminum, Au, and Ag, -- a film -- vacuum evaporationo, a spatter, plating, etc. -- 1 micrometer It forms approximately and lead wire 13 is formed by photolithography and etching. Finally a chip is cut, and it is processed according to production processes, such as polishing, on X-X-ray, and is made the configuration of the predetermined magnetic head.

[0028] [Example 2] Drawing 2 is the thin film magnetic head 16 which set up the gap (MAG) 7 between the top core 9 and middle core 8a. In this thin film magnetic head 16, the spacer 14 is formed between the top core 9 and middle core 8a.

[0029] [Example 3] Drawing 3 is the thin film magnetic head 17 which consisted of core 8a-2 and 8b-2 between core 8a-1, 8b-1, and Kaminaka between the two-layer coil pattern 10-1, 10-2, and two-layer Shimonaka, and set up the gap (MAG) 7 between core 8a-1 between the bottom core 4 and Shimonaka. This thin film magnetic head 17 has formed the

spacer 14 between core 8a-1 between the bottom core 4 and Shimonaka.
[0030] [Example 4] Drawing 4 is the thin film magnetic head 18 which consisted of core 8a-2 and 8b-2 between core 8a-1, 8b-1, and Kaminaka between the two-layer coil pattern 10-1, 10-2, and two-layer Shimonaka, and set up the gap (MAG) 7 among core 8a-2 between core 8a-1 and Kaminaka between Shimonaka. In this thin film magnetic head 18, the spacer 14 is formed among core 8a-2 between core 8a-1 and Kaminaka between Shimonaka.
[0031] [Example 5] Drawing 5 is the thin film magnetic head 19 which consisted of core 8a-2 and 8b-2 between core 8a-1, 8b-1, and Kaminaka between the two-layer coil pattern 10-1, 10-2, and two-layer Shimonaka, and set up the gap (MAG) 7 among core 8a-2 between the top core 9 and Kaminaka. In this thin film magnetic head 19, the spacer 14 is formed among core 8a-2 between the top core 9 and Kaminaka.
[0032] Also in the thin film magnetic heads 14-17 shown in examples 2-5, a flat insulating layer is accumulated, and since the magnetic layer formed in the predetermined part in these insulating layers is connected and the magnetic circuit is formed, a photolithography becomes possible in respect of each insulating layer without a level difference. Therefore, since small coil pattern and magnetic core which was excellent in dimensional accuracy are obtained, magnetic reluctance is low and becomes possible [obtaining the powerful thin film magnetic head].
[0033] Furthermore, since thickness L of the perpendicular direction from the data-medium opposed face of middle core 8a does not become thin with a spacer 14 even if it sets up a life size (l in drawing) short, there is no partial magnetic-flux saturation of a core, and it becomes high coercive force data medium recordable. Moreover, since the leakage of magnetic flux can be decreased by forming a spacer (layer) 14, an efficient recording characteristic is acquired. Furthermore, since the magnetic field for a head point (a near gap) concentrates at the tip of a gap by making edge 14a of a spacer 14 into a taper configuration, efficient writing is attained.
[0034]
[Effect of the Invention] The middle core to which the thin film magnetic head which becomes this invention connects a bottom core, a top core, and these is constituted by the magnetic substance in an insulating layer. In the thin film magnetic head which the surface of each of said insulating layer including the connection side of each of said core is abbreviation flatness, and comes to form a gap in the connection of said core Since a spacer layer thicker than a gap layer is formed between the cores which sandwich a gap and the thickness of the perpendicular direction from the data-medium opposed face of the core which sandwiches a gap with a spacer does not become thin even if it sets up a life size short Since there is no partial magnetic-flux saturation of a core, it becomes high coercive force data medium recordable and the leakage of magnetic flux can be further decreased with a spacer, an efficient recording characteristic is acquired.

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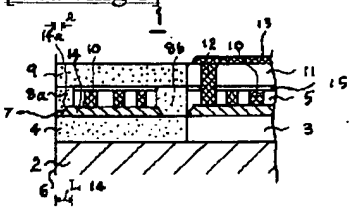
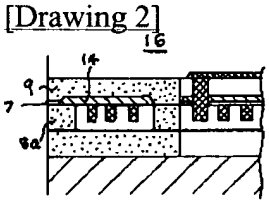
DRAWINGS

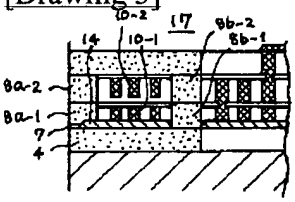
[Drawing 1]



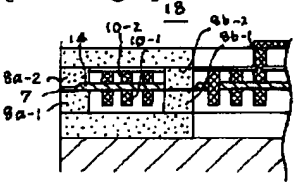
[Drawing 2]



[Drawing 3]



[Drawing 4]



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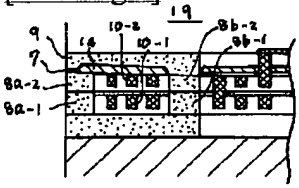
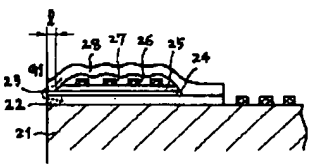
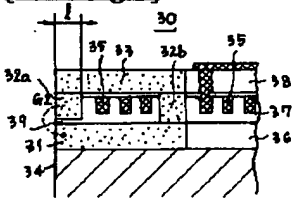


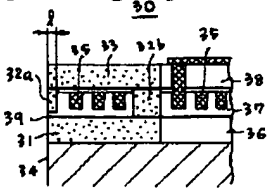
[Drawing 8]



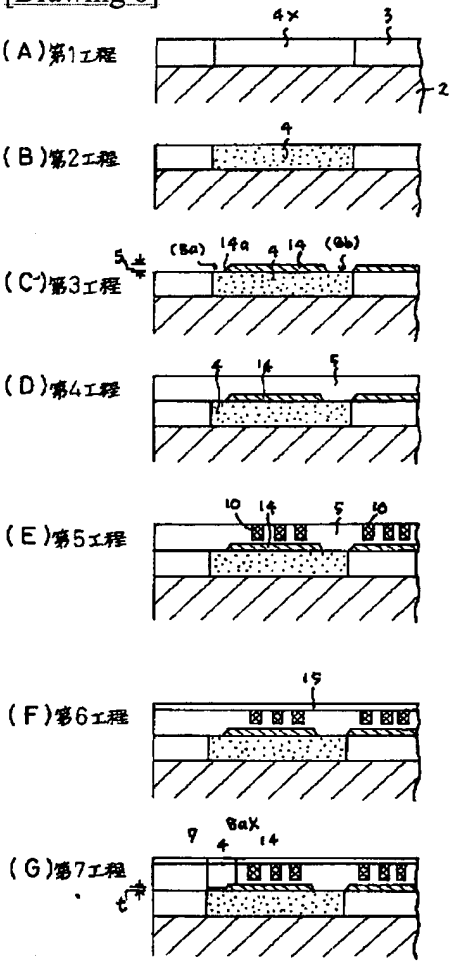
[Drawing 9]



[Drawing 10]

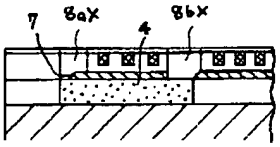


[Drawing 6]

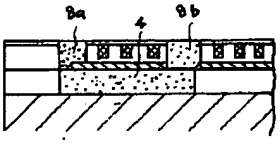


[Drawing 7]

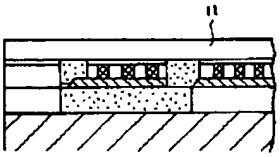
(A)第8工程



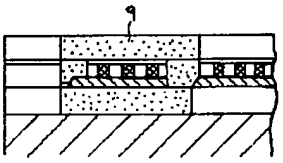
(B)第9工程



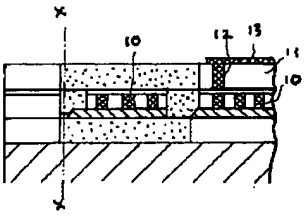
(C)第10工程



(D)第11工程



(E)第12工程



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* NOTICES *

CORRECTION OR AMENDMENT

[Official Gazette Type] Printing of amendment by convention of 2 of Article 17 of patent law
[A section partition] The 4th partition of the 6th section
[The date of issue] October 18, Heisei 6 (1994)

[Publication No.] Publication number 5-6514
[Date of Publication] January 14, Heisei 5 (1993)
[Year copy format] Open patent official report 5-66
[Filing Number] Japanese Patent Application No. 3-183791
[The 5th edition of International Patent Classification]

G11B 5/31 C 8947-5D

[Procedure revision]
[Filing Date] March 18, Heisei 6
[Procedure amendment 1]
[Document to be Amended] Specification
[Item(s) to be Amended] 0013
[Method of Amendment] Modification
[Proposed Amendment]
[0013] Moreover, the up insulating layer 11 is formed on said middle insulating layer 5, the top core 9 is formed in this up insulating layer 11 so that both ends may join to the middle cores 8a and 8b, and the magnetic circuit is formed with said bottom core 4. Furthermore, between the bottom core 4 which sandwiches a gap 7, and middle core 8a, the spacer layer 14 (thickness s) thicker than a gap (layer) 7 (thickness t) is formed on the bottom core 4 (t<s). The thickness of edge 14a of the spacer layer 14 decreases toward a head point (the record-medium opposed face 6, gap 7), and edge 14a of the spacer layer 14 is a taper-like.
[Procedure amendment 2]
[Document to be Amended] Specification
[Item(s) to be Amended] 0029
[Method of Amendment] Modification
[Proposed Amendment]
[0029] [Example 3]
Drawing 3 is the thin film magnetic head 17 which consisted of core 8a-2 and 8b-2 between core 8a-1, 8b-1, and Kaminaka between the two-layer coil pattern 10-1, 10-2, and two-layer Shimonaka, and set up the gap (MAG) 7 between core 8a-1 between the bottom core 4 and Shimonaka. This thin film magnetic head 17 has formed the spacer 14 between core 8a-1 between the bottom core 4 and Shimonaka.
[Procedure amendment 3]
[Document to be Amended] Specification
[Item(s) to be Amended] Explanation of a sign
[Method of Amendment] Modification
[Proposed Amendment]
[Description of Notations]
1 Thin Film Magnetic Head
2 Substrate

3 Lower Insulating Layer
4 Bottom Core
5 Middle Insulating Layer
6 Record-Medium Opposed Face
7 (MAG) Gap
8 Middle Core
8a-1, 8b-1 The Shimo middle core
8a-2, 8b-2 Core between Kaminaka
9 Top Core
10 Coil Pattern
10-1, 10-2 Coil pattern
12 Conductor
14 Spacer (Layer)
14a The edge of a spacer (layer)
15 Insulating Layer
16-19 Thin film magnetic head
s Thickness of a spacer (layer)
t Thickness of a gap (gap length)
l Life size (depth of gap)

[Translation done.]